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Handling and Shipping Southern-Grown Tomato Plants

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CONTENTS

IMPORTANCE AND TRANSPORTATION PROBLEMS OF TOMATO-PLANT INDUSTRY

During the past 20 years the growing of vegetable plants (seedlings) in the South for shipment to the Northern States has developed into a relatively large industry. Formerly such plants were grown mostly in greenhouses in the North, but now they are grown more cheaply and more satisfactorily in several of the Southern States, where they are field-hardened at pulling time.

[1] The work reported herein was done under the general direction of D. F. Fisher, principal horticulturist, in charge of investigations on the handling, transportation, and storage of fruits and vegetables, Division of Fruit and Vegetable Crops and Diseases. The authors are indebted to the following: B. D. Ezell, M. H. Haller, L. P. McColloch, G. B. Ramsey, G. Lee Roberts, D. H. Rose, H. Rex Thomas, LeRoy Wheeler, T. M. Whiteman, R. C. Wright, of the Division of Fruit and Vegetable Crops and Diseases; G. M. Stone, formerly of the Plant Disease Survey; and C. F. Rainwater, Bureau of Entomology and Plant Quarantine; Railway Express Agency, Inc.; Fruit Growers Express Co.; Delta Air Lines; Campbell Soup Co.; Louden Packing Co.; Stokely Foods, Inc.; Francis Stokes Co.; and Joseph Campbell Co.

823514°—49——1

Several different types of vegetables are grown to sell as seedlings, but tomato plants are produced in the greatest quantity because of the great demand for early plants by growers of cannery stock in the North. Beginning as a mail-order business about 30 years ago, the growing of seedling tomato plants has increased to such an extent that now total shipments by both truck and rail are the equivalent of more than 1,000 carloads a year.

Tomato plants are grown commercially in Georgia, Florida, Mississippi, and Texas. In several counties in the southern part of Georgia plant growing has become a major industry, the extent of which is shown in table 1. If it is assumed that 500,000 plants were shipped per car and that the less-than-carload lots averaged half this number, about half a billion plants were shipped from Georgia by railroad in 1945, the year when the most plants were shipped.

TABLE 1.—*Record of acreage planted and carload shipments of tomato plants for Georgia for 1939–46* [1]

Year	Area planted	Pull per acre	Solid-carload shipments	Less-than-carload shipments	Total cars involved
	Acres	*Number*	*Number*	*Number*	*Number*
1939			216	641	857
1940			166	582	748
1941			222	563	785
1942	5, 806	101, 342	226	705	931
1943	6, 709	80, 876	385	837	1, 222
1944	5, 453	99, 800	435	651	1, 086
1945	8, 030	79, 521	690	585	1, 275
1946	10, 163	72, 182	482	239	721

[1] Acreage figures supplied by Georgia Department of Entomology and carload-shipment ones by the Railway Express Agency, Inc.

Originally rail shipments of tomato plants were made in baggage cars with the doors open slightly to insure ventilation. The rate of growth of the industry indicated that the supply of baggage cars would soon become inadequate and that such cars would need to be supplemented or replaced with cars of another type. World War II hastened this eventuality and refrigerator cars had to be used.

When the outside temperatures are high, ventilation does not cool the plants. Such high temperatures are conducive to the development in transit of early blight, a disease caused by the fungus *Alternaria solani* (Ell. and G. Martin) Sor., if any stem cankers happen to be present on the plants when they are packed. Infections that occur during transit may not become evident until the plants are set out. Then, particularly, if the period after planting is cool and wet, the stems break over, the stand is poor, and the grower loses time and money. Moreover, cooled plants unloaded when the temperature is relatively warm frequently sweat.

Study of railroad transportation of tomato plants was begun in 1940 at Tifton, Ga. The main object of the tests was to determine whether (1) plants are cooled adequately by ventilation, (2) accumulation of carbon dioxide in the cars from respiration of the plants is sufficient to weaken them, and (3) plants shipped in iced refrigerator cars (standard end-bunker refrigerator cars without forced-air circulation unless stated otherwise) can be delivered in better condition than those shipped in ventilated cars. In 1945 test shipments by airplane were made because of the losses resulting from the arrival of rail shipments when the weather was unfavorable for planting.

GROWING AND PREPARING PLANTS FOR SHIPMENT

Growing the Plants

Tomato plants are grown in southern Georgia during the early spring only. The soil is plowed and harrowed thoroughly in order to insure a clean, uniform seedbed. Seeding usually begins about February 20 and continues until about April 1. The seeds are drilled four, five, or six abreast in wide rows 14 or 16 inches apart. Rates of seeding vary according to the variety being grown but average 3 to 5 pounds of seeds per acre.

As soon as the young seedlings show the first set of true leaves, spray applications of a fungicide acceptable to the certification authorities are begun, and these are continued at approximately 10-day intervals until the seedlings are pulled. Cost of growing tomato seedlings varies from farm to farm but usually runs from $100 to $150 per acre.

For the protection of growers and in the interest of buyers, the Fruit and Vegetable Branch, Production and Marketing Administration, United States Department of Agriculture, has established standards for grades and provides for inspection and grading of tomato plants. No. 1 grade plants are of good quality, of uniform size, and free of disease and excessive other damage. Likewise Georgia has a State certification service, of the Department of Entomology, to insure shipment of good, disease-free plants. Included in this service are inspections throughout the production period, from seeding until the plants are packed and ready for shipment. Both of these services are voluntary, and information regarding them may be obtained from the respective organizations mentioned.

Pulling and Packing the Plants

When the plants are 6 to 9 inches high, they are pulled by hand (fig. 1) and tied in bundles of 50. These bundles are put into burlap bags (fig. 2) and hauled to the packing house. There the bundles are opened, sorted, and reassembled into bunches of 100 each. The bunches are then rolled in wet moss peat (fig. 3) and wrapped in paper, which may be held in place by a string or a rubber band, and 4 or 5 bunches are packed in a 5/8-bushel hamper (fig. 4). In some houses long weystone-shaped crates (fig. 5) or used instead of hampers. These crates are packed with 10 to 14 bunches. The hampers or crates are loaded into cars for shipment (fig. 6).

FIGURE 1.—When the tomato plants are 6 to 9 inches high they are pulled by hand.

FIGURE 2.—The pulled tomato plants are tied in bundles and placed in burlap bags.

FIGURE 3.—At the packing house the tomato plants are sorted (*A*) and then rolled in wet moss peat and wrapped in paper (*B*).

FIGURE 4.—The wrapped tomato plants are packed in ⅝-bushel hampers (*A*) and the lids secured (*B*).

FIGURE 5.—Sometimes the tomato plants are packed in keystone-shaped crates.

FIGURE 6.—Hampers of tomato plants are stacked in refrigerator cars for shipment. For proper cooling they should not be stacked higher than the bottom of the top opening of the end bunkers. This load is one layer higher than is advisable.

SHIPPING THE PLANTS

Ventilation Versus Refrigeration

At the time of the first tests considerable objection to cooling of tomato plants existed among growers and shippers. The belief was held that tomato plants must be transported at temperatures high enough to induce root growth during transit, and receivers were reluctant to accept plants that had not initiated new growth of roots during transit. Growers in the North objected to cooled plants also

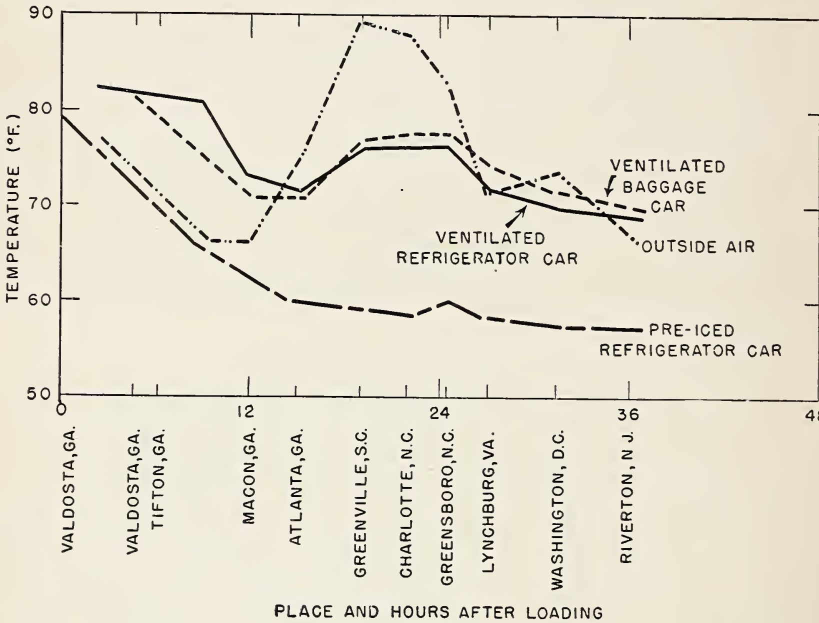

Figure 7.—Comparison of outside-air temperatures with temperatures of tomato plants shipped by ventilated baggage car, ventilated refrigerator car, and refrigerator car pre-iced with 8,000 pounds of ice. (Note that cars were not loaded simultaneously.)

because they believed that sweating of these plants when unloaded during relatively warm weather resulted in weakened plants with lowered survival rate.

The first experimental shipments of tomato plants, made in 1940, consisted of a ventilated baggage car, a standard ventilated refrigerator car, and a standard end-bunker refrigerator car pre-iced with 8,000 pounds of ice. The vents in the pre-iced car were closed during the first 18 hours of the trip. Electric resistance thermometers were installed in all test cars to determine the commodity and inside-air temperatures during transit. Outside-air temperatures were obtained by mercury thermometers and were recorded at every stop by observers accompanying the test cars.

The temperature records of the first test are shown in figure 7. The outside-air temperature reached its peak shortly after noon of the

second day, or about 18 hours after loading. The plant temperatures in the two ventilated cars showed a fluctuation similar to that of the outside air, though not so great. At the time of loading, the air and plant temperatures were about 80° F. Temperatures of the plants in the ventilated cars remained in the 70° to 80° range during the entire trip. The effects of refrigeration in lowering the temperature of the plants during transit can be observed in the curve showing temperatures in the refrigerated car. In about 15 hours after loading the plant temperatures had dropped to 60°, and they remained within the 50° to 60° range during the entire trip.

Tests for carbon dioxide showed no measurable accumulation in either of the ventilated cars. Carbon dioxide reached a concentration of 2.5 percent in the refrigerated car during the first 18 hours when the vents were closed, but it quickly dissipated when the vents were opened.

Effect of Cooling on Growth

Storage tests [2] indicated that tomato plants could be held for 2 to 4 days at 50°, 60°, and 70° F. without serious retardation of growth after transplanting. When they were held for the same time at 40° or 80°, growth was considerably retarded (fig. 8). Retardation of growth at these temperatures varied directly with the length of the storage period.

Little or no new root growth was made by the plants stored at 50° to 60° F. An attempt was made to counteract this retarding effect

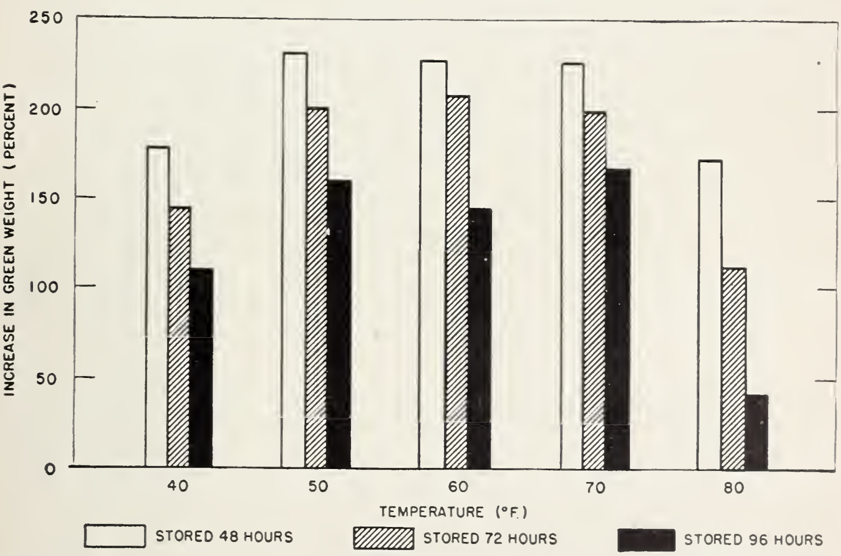

Figure 8.—Percentage increase in green weights of tomato plants after 4 weeks growth in field, which followed storage at 40°, 50°, 60°, 70°, and 80° F. for 48, 72, and 96 hours. (Results obtained by W. D. Moore, Tifton, Ga., 1942.)

[2] Tests conducted by W. D. Moore, Tifton, Ga., 1942.

823514°—49——2

of refrigeration on growth of new roots by treating the plants with growth-promoting compounds (3-indoleacetic acid, β-naphthalene oxyacetic acid, α-naphthaleneacetic acid, and vitamin B_1 in various concentrations). Although several treatments, especially those with 3-indoleacetic acid and α-naphthaleneacetic acid, appeared to stimulate root development under laboratory conditions, the field results showed no benefits from the treatments (table 2). On the other hand, the results of these tests indicate that, although temperatures of 50° to 60° suppress the formation of new roots, they do not retard subsequent growth of tomato plants. Furthermore, field tests in 1942 demonstrated that the new lateral roots formed at the higher temperatures after pulling and before transplanting were of no value to the plant.

TABLE 2.—*Effect of growth-promoting substances on growth of tomato plants held in pony refrigerator under ice at 50°–60° F. for 4 days, 1942*

Treatment	Average weight after 4 weeks in field			
	Experiment 1		Experiment 2	
	Plants	Roots	Plants	Roots
	Gm.	*Gm.*	*Gm.*	*Gm.*
Refrigeration plus growth-promoting solutions	133. 6	17. 8	146. 8	22. 2
Refrigeration only	144. 0	18. 5	167. 7	21. 5
None (temperature approximately 70°)	148. 8	19. 0	174. 6	23. 6

Treatment	Average weight after 4 weeks in field			
	Experiment 3		Experiment 4	
	Plants	Roots	Plants	Roots
	Gm.	*Gm.*	*Gm.*	*Gm.*
Refrigeration plus growth-promoting solutions	119. 3	19. 1	35. 2	7. 8
Refrigeration only	121. 3	21. 0	34. 0	7. 2
None (temperature approximately 70°)	114. 2	21. 0	38. 5	8. 9

When two similar lots of plants were held for several days at approximately 70° and 50° to 60°, respectively, new roots developed at 70° but none developed at 50° to 60°. The plants were transplanted to a field and after 2 weeks were dug and weighed. There was no marked difference in the two lots (table 3). Research work at various State agricultural experiment stations has verified these results, and efforts are now being made to suppress root development during the shipping period in order to conserve the vigor of the plants.

TABLE 3.—*Increase in green weight of tomato plants held at approximately 70° F. until they had a heavy growth of new roots and of those held at 50°–60° to inhibit new roots and allowed to grow 2 weeks after transplanting, 1942*

Replicate	Increase in weight of plants with—	
	Heavy growth of new roots	No new roots
	Percent	*Percent*
1	68. 1	61. 9
2	57. 1	72. 0
3	61. 4	69. 3
4	62. 7	70. 1
5	50. 0	47. 7
6	60. 8	44. 6
Average	60. 0	60. 9

TEST SHIPMENTS IN REFRIGERATOR CARS

The cooling tests just described established the fact that relatively low temperatures are not harmful to tomato plants for the short time required to ship them to the usual northern destinations. In fact, the tests showed that holding plants in the 50° to 70° F. range is desirable and that holding them at 80° produces ill effects. In addition, in the preliminary transportation tests the refrigerated plants always arrived in a fresher and greener condition than did the nonrefrigerated ones. From 1943 to 1945 test shipments in the East and to the Middle West were confined to carload shipments and a total of 80 carloads of tomato plants were used in the investigations. The object of these later tests was to determine the best method of maintaining plant temperatures in the range of 50° to 70° during the greater part of the transit period.

SHIPMENTS IN THE EAST

Test shipments were made in the East in 1943 and 1944. During the 1943 season 6,000 pounds of ice was used in the refrigerated cars. This amount was chosen because calculations based on the field heat and heat of respiration of tomato plants, plus the probable leakages through the car walls, indicated that 6,000 pounds of ice would be necessary to reduce the temperature of a carload of tomato plants from 85° to 60° in 3 days. The test shipments also included carloads of plants shipped under standard ventilation to compare with the iced loads.

Figure 9 shows the results obtained from shipping tomato plants in the East with 6,000 pounds of ice divided equally between the two end bunkers and with vents closed to destination. It will be noted that transit temperatures were not satisfactory in this test, at least in the top layer of plants, where they remained near 80° F. all the way. Average temperatures in the bottom layer dropped to 70° in about 18 hours and continued to drop until they reached 65° at destination after about 42 hours. The wide spread in temperature between the top and bottom layers was undesirable. An attempt to correct this spread was made by placing 6,000 pounds of ice in the upper part of the bunkers (stage icing). This method of icing tended to lower the temperature of the top layer, at least for a while, but it did not cool the

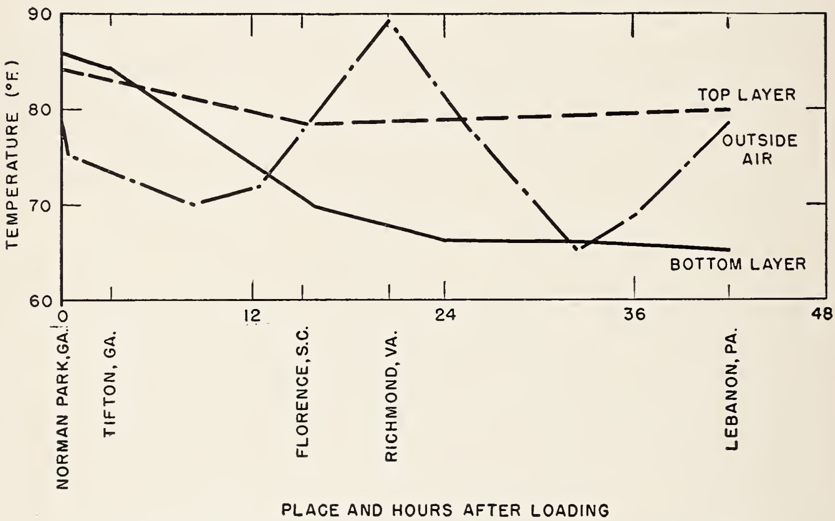

FIGURE 9.—Temperatures of outside air and of tomato plants shipped from Georgia to Pennsylvania, pre-iced with 6,000 pounds of ice, vents closed to destination.

bottom layer sufficiently (fig. 10). The temperatures of the top and bottom layers were closer together, and although the total cooling of the load was no greater than in the preceding test the temperatures were more satisfactory for tomato plants.

In figure 11 are the results of pre-icing with 6,000 pounds of ice in a fan car that provided forced air circulation through the load. In this type of car there are fans under the floor racks near each end of the car. The fans are driven by belts from a friction-drive wheel held in contact with the car wheels so that the fans are operated whenever the car is in motion.

When these fans are in operation, a forced air circulation from the bunkers to the loading space is established and the normal direction of the air movement is reversed so that the coldest air goes to the top of the load, where it is needed most. When the car is not in motion the air movement is slow and is similar to that in nonfan cars. In this test the temperatures of both top and bottom layers of plants began dropping soon after the train started moving, and they remained within

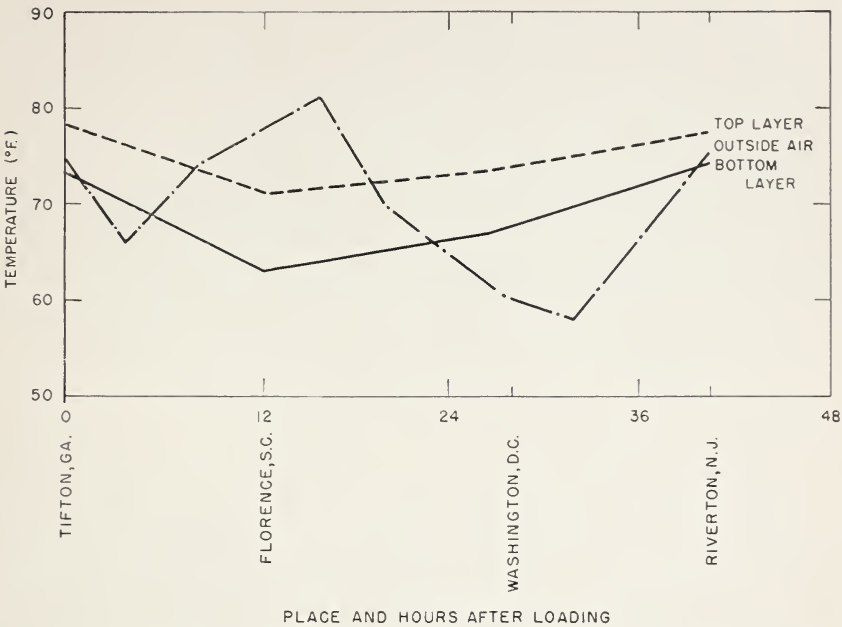

FIGURE 10.—Temperatures of outside air and of tomato plants shipped from Georgia to New Jersey, pre-iced with 6,000 pounds of ice (upper stage), and with vents closed to destination.

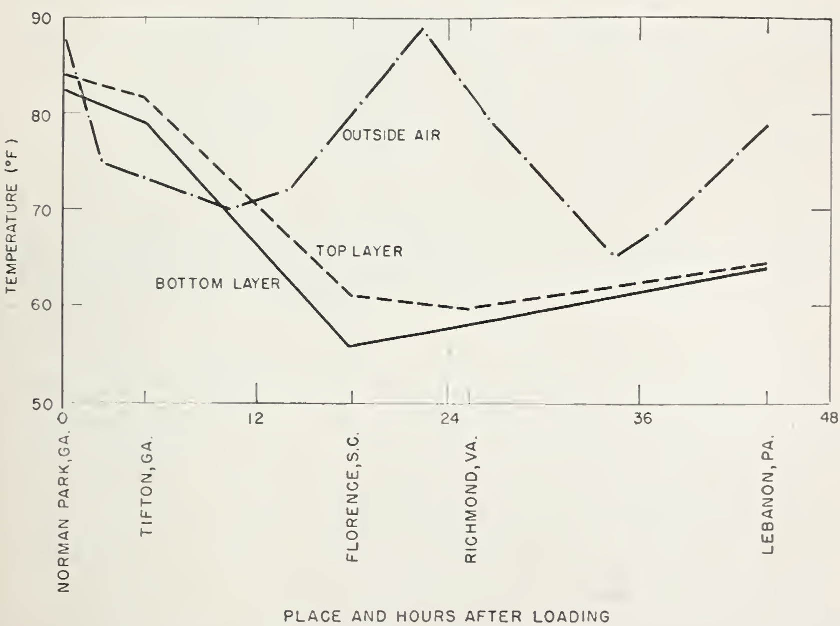

FIGURE 11.—Temperatures of outside air and of tomato plants shipped from Georgia to Pennsylvania in Preco fan cars, pre-iced with 6,000 pounds of ice and with vents closed to destination.

50° to 70° F. range during the greater part of the trip. It should be noted that the similarity of the two curves in this instance demonstrates the greater efficiency of cooling in the fan car. This was accomplished despite the fact that the plant temperatures at the time of loading were high, ranging from 80° to 90°. The resulting temperatures throughout the load were satisfactory for tomato plants.

At the beginning of the 1944 season a provision for icing tomato plants was included in the tariff by the Railway Express Agency, Inc., but the amount of ice was limited to 5,000 pounds. Consequently, the tests conducted during 1944 were with 5,000 pounds of ice instead of 6,000 pounds, which had been used in the previous year's tests. In the first tests of 1944 the vents of the refrigerated cars were kept

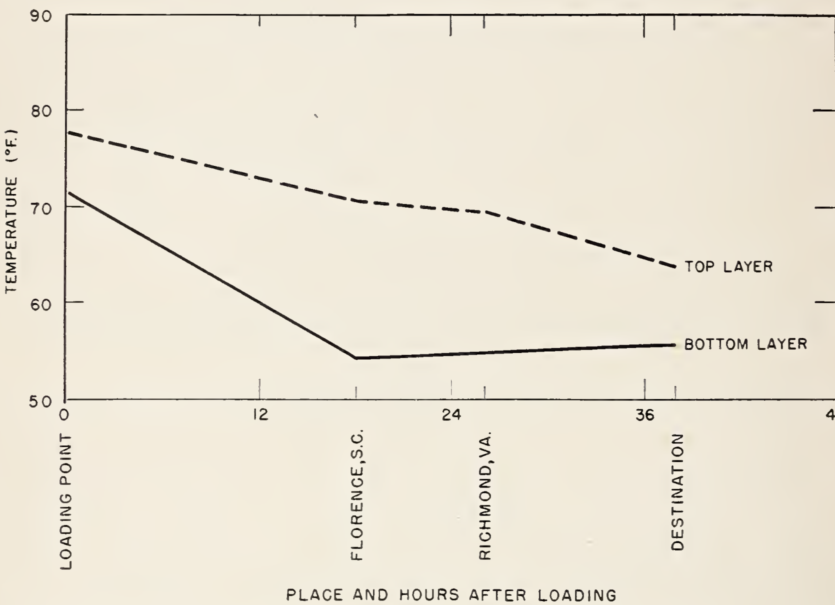

FIGURE 12.—Temperatures of tomato plants shipped from Georgia to other points in the east, pre-iced with 5,000 pounds of ice, vents closed to Richmond, Va., and open thereafter (average of five test shipments).

closed to Richmond, Va., but were kept open thereafter. The results of these tests appear in figure 12. It will be noted that the bottom layer of plants remained in the 50° to 70°F. range practically the whole time, whereas the top layer dropped to this range only in the latter half of the trip. Other tests were later conducted in which the vents were kept open from loading point to destination (fig. 13). This method proved more satisfactory because both top and bottom layers remained in the 50° to 70° range during most of the trip. It should be borne in mind, however, that at the time of loading these test shipments, the outside-air temperatures were moderate for the time of year, being in the 70° to 80° range. If air temperatures had been in the 80° to 90° range, as sometimes occurs, 5,000 pounds of ice would not have been enough to maintain these temperatures during transit.

The temperature of plants shipped under standard ventilation depends upon the outside-air temperatures. If air temperatures are above those recommended for holding tomato plants, the plants may be damaged in transit. If the weather is cool, however, plants may be shipped safely without refrigeration.

As a result of the 1944 season's work, the United States Department of Agriculture recommends that in shipping tomato plants in the East with 5,000 pounds of ice in the bunkers of standard end-bunker cars the diagonally opposite vents be open to destination, but that provision be made for some flexibility in the amount of ice permitted, because more ice would be required if air temperatures were higher than they were in 1944.

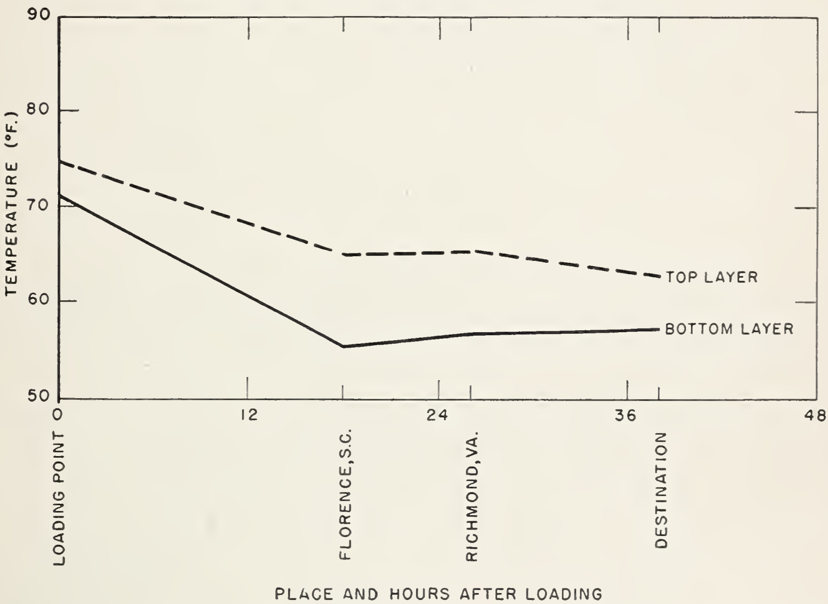

FIGURE 13.—Temperatures of tomato plants shipped from Georgia to other points in the East, pre-iced with 5,000 pounds of ice, vents open to destination (average of three test shipments).

SHIPMENTS TO THE MIDDLE WEST

In 1944 and 1945 test shipments were made from Georgia to the Middle West. Not all of the data collected on the midwestern shipments will be presented, because a number of exploratory tests were made before a satisfactory method was developed. It should also be mentioned that shipments to the Middle West, usually starting 10 to 20 days later than those to eastern points, are customarily made during much warmer weather. This imposes greater demands upon refrigeration if temperatures are to be maintained within the desired range of 50° to 70° F.

Several tests were conducted during 1944 with standard ventilation and with 5,000, 6,000, 7,000, and 8,000 pounds of ice. In the refrigerated cars the vents were closed to Etowah, Tenn., or Cincinnati,

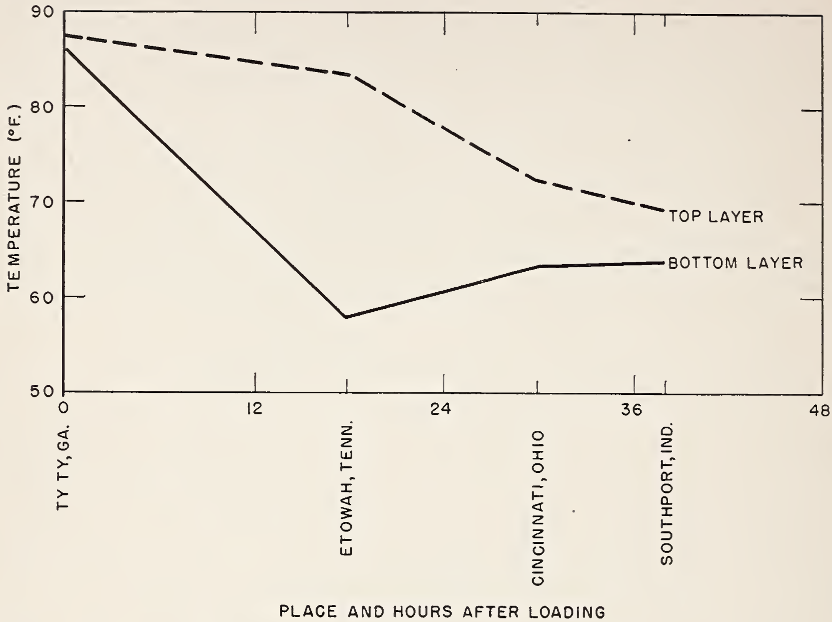

FIGURE 14.—Temperatures of tomato plants shipped from Georgia to the Middle West, pre-iced with 7,000 pounds of ice, vents closed to Etowah, Tenn., and open thereafter.

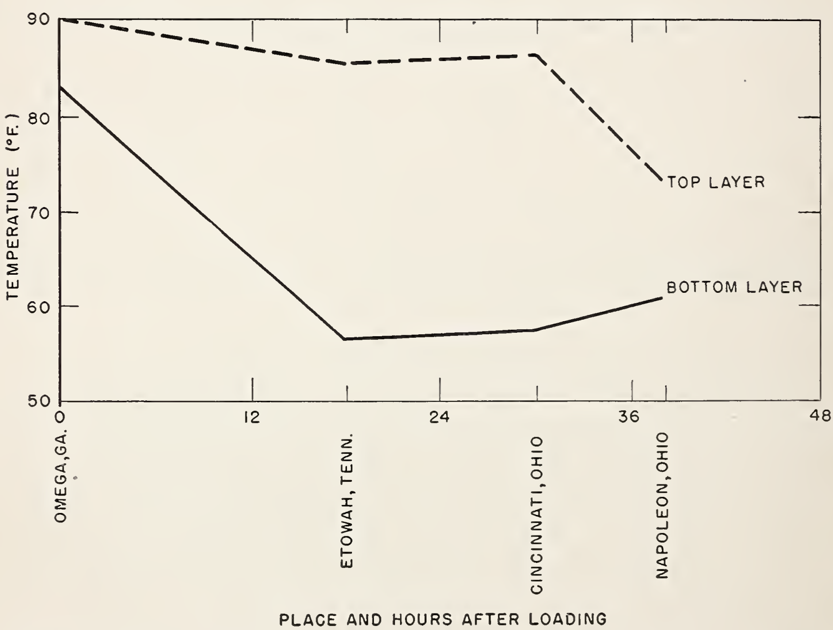

FIGURE 15.—Temperatures of tomato plants shipped from Georgia to the Middle West, pre-iced with 8,000 pounds of ice, vents closed to Cincinnati, Ohio, and open thereafter (average of two test shipments).

Ohio, and kept open thereafter. Temperatures in the cars under standard ventilation were uniform and there were only 2° to 3° F. differences between the top and bottom layers. However, they remained in the 75° to 85° range during the transit period. This range is considered too high. In all of the refrigerated tests only the bottom layer of plants was satisfactorily cooled (figs. 14 and 15). When 9,000 pounds of ice was used, however, the temperature of the top layer was satisfactory but that of the bottom layer was too low (fig. 16). Since this method did not allow uniform cooling in the cars, manipulation of the vents was varied with better results. The most

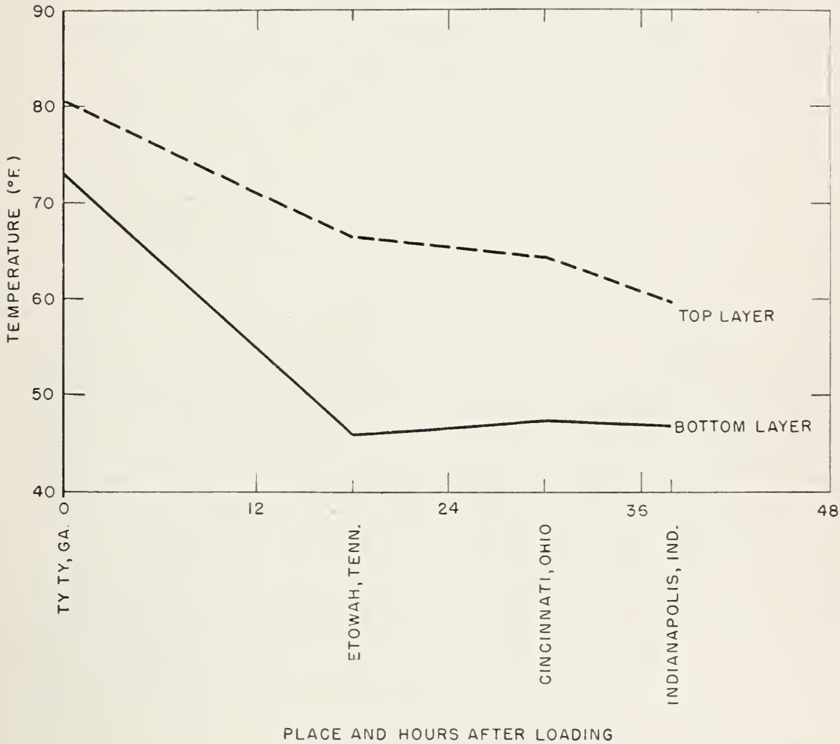

FIGURE 16.—Temperatures of tomato plants shipped from Georgia to the Middle West, pre-iced with 9,000 pounds of ice, vents closed to Cincinnati, Ohio, and open thereafter.

satisfactory temperatures were obtained by pre-icing with 7,000 pounds of ice, opening diagonally opposite forward and rear vents 3 inches to Cincinnati, and opening all vents thereafter (fig. 17). It is desirable to have the temperatures of the top and bottom layers closer together, but this can be accomplished only in fan cars and not many of these were available when the tests were made.

During the tests in 1945 it was found that it was not necessary to change the position of the vents during transit. Satisfactory results were obtained when the cars were pre-iced with 7,000 pounds of ice and the diagonally opposite forward and rear vents were opened 4

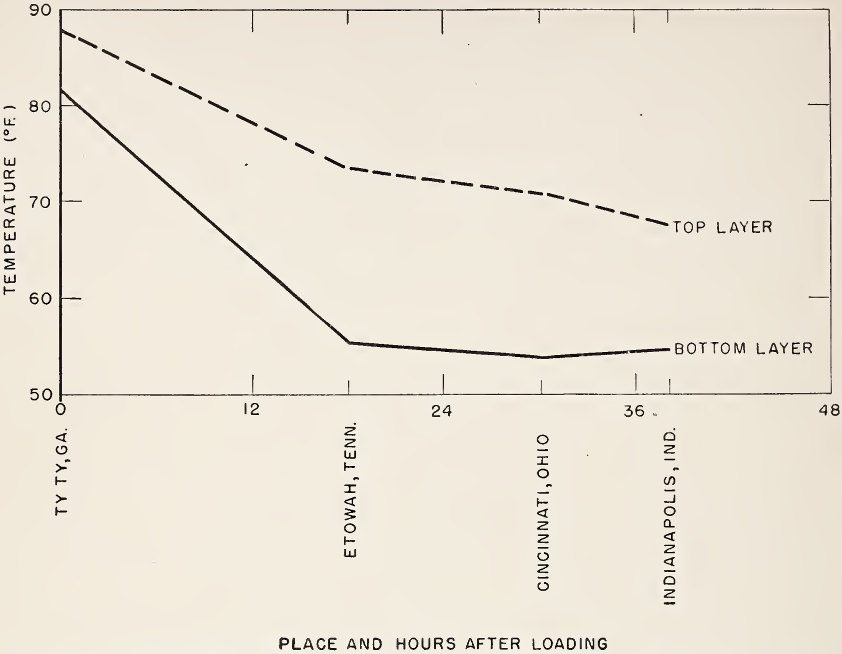

FIGURE 17.—Temperatures of tomato plants shipped from Georgia to the Middle West, pre-iced with 7,000 pounds of ice, left forward and right rear vents open 3 inches to Cincinnati, Ohio, and all vents open thereafter (average of two test shipments).

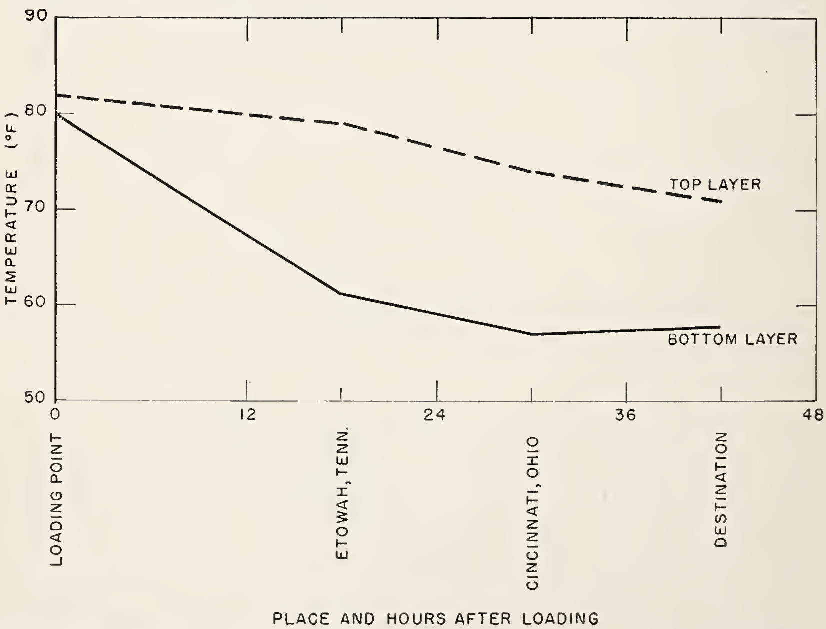

FIGURE 18.—Temperatures of tomato plants shipped from Georgia to the Middle West, pre-iced with 7,000 pounds of ice, left forward and right rear vents open 4 inches from loading point to destination (average of six test shipments).

inches from loading point to destination (fig. 18). This method is therefore recommended for shipments of tomato plants from Georgia to the Middle West.

CONDITION OF PLANTS AT DESTINATION

The arrival of tomato plants in poor condition can often be attributed to faulty methods of packing. Good, clean plants of uniform size should be selected, and weeds and excess soil should be removed from the roots before the plants are packed in moist peat, or sphagnum moss.

In general the plants shipped under modified refrigeration arrived with a fresher appearance than those shipped under standard ventilation. Plants shipped under ventilation were all described as "fairly good to good," while those shipped under refrigeration were considered "good to very good." There was a little wilting of the outer leaves in hampers of both types of shipment, and yellowing of leaves was found in cars with the hampers stacked six high, irrespective of whether ice was used. The plants that were slimy at destination were usually so small and immature that they should not have been shipped. Large, hardened plants rarely showed any decay.

Improper loading of hampers may result in high plant temperatures in transit or in unsatisfactory appearance and condition of plants upon arrival at destination (figs. 6, 19, and 20). Hampers should be stacked firmly but in such a way as to permit free circulation of air within the car. They should never be stacked higher than the bottom of the top bulkhead opening of the ice bunker. In most cars this will prohibit the stacking of hampers six high. In some instances the hampers stacked six high leave only 3 or 4 inches clearance between the top of the hampers and the ceiling of the car; this prevents adequate circulation of air and should be avoided. In the test shipments reported in this circular, no effort was made to have the regular loading practices changed. The temperature equipment was placed in the cars without influencing regular loading practices.

When refrigerator cars were first used, shippers found it necessary to load between 420,000 and 520,000 plants in a car in order to meet the minimum load requirements based on the customary load in a baggage car, which is larger than a refrigerator car. In loads of large plants 400 plants were packed per hamper and more hampers were required to meet the minimum weight than when smaller plants (500 per hamper) were packed. This often necessitated making the load 6 hampers high.

Under the recently revised tariff of the Railway Express Agency, Inc., this heavy loading is not necessary. The minimum rate provides for a load of 11,000 pounds in 40-foot cars and 13,000 pounds in larger cars. Because of the difference in the size of the plants the weight of a hamper containing 400 plants averages 17.8 pounds and that of a 500-plant hamper 16.8 pounds. On this basis the minimum load requirements for freight refrigerator cars can be met by loading 250,000 to 350,000 plants, or 625 to 650 hampers. In larger cars only 300,000 to 400,000 plants, or 725 to 775 hampers, need be loaded. Loads of such size could be used without stacking the hampers more than 4 layers high. Generally the refrigerator cars are so constructed that

FIGURE 19.—Appearance of test shipment of tomato plants at destination when hampers had been improperly stacked during loading. Hampers beneath car fell out when doors were opened. Suitcase in doorway was for temperature equipment seen at top of doorway.

FIGURE 20.—Appearance of test shipment of tomato plants at destination when crates had been improperly stacked during loading.

hampers may be stacked 5 high without interfering with air circulation through the top openings of the bunkers. A load 5 high would contain many more plants than the minimum requirement.

Some of the overloaded cars used in the test shipments contained over 1,200 hampers. In the test cars of 1944 the average number of hampers was 873 and the maximum number was 1,225, while the average for 1945 was 1,222.

In 1944 and 1945 tomato plants from both ventilated and refrigerated cars and from the warmest and the coldest parts of the cars were set out in experimental plots in New Jersey and Indiana for subsequent observation. Weather conditions at the time that these experimental plants were set out were not favorable to plant growth, so the field trials were not satisfactory from an experimental standpoint. The fact that no significant difference in the rate of growth was noted in the different lots of plants is not regarded as conclusive evidence that transit temperatures had no effect on the yield of tomatoes at harvest. Work along this line should be done under close supervision and under controlled conditions.

Airplane Shipments

In 1945 two test shipments of tomato plants were made by airplane. The requests for these tests came from shippers who were suffering heavy losses in tomato plants because of delays in transplanting due to unfavorable weather conditions. Early-spring growing conditions in Georgia, together with heavy rains, produced tall, succulent plants which the growers were anxious to move. In the North the weather was generally unfavorable and the season for planting was backward, so that the southern-grown tomato plants often arrived during periods of cold, wet weather. The abnormal succulence, or "softness," of the tomato plants made them particularly subject to damage and loss from protracted delays in transplanting.

In order to overcome this condition some growers and shippers considered transporting, and to some extent did transport, tomato plants by air. Since this type of transportation would shorten the period between pulling and planting, growers in the North could order plants on much shorter notice and thereby take advantage of ideal local weather conditions. This would result in less opportunity for deterioration of plants in transit and would thus furnish fresher plants for transplanting.

The plane used in these tests was a Douglas transport (DC–3) which had been transferred from the Army Air Forces to a commercial line. The ship had not yet been converted for passenger traffic. The capacity of the cabin was 1,300 cubic feet, the pay load 6,000 pounds, and the cruising speed 180 miles per hour. Both tests were made from Tifton, Ga., to Bowling Green, Ohio. The actual flying time was about 5 hours. The entire period between loading and unloading at destination was about 6 hours.

The tomato plants used in the test shipments were prepared in four ways, as follows:

(1) Wrapped in wet moss peat, 100 to a bundle, which was covered by paper and tied, and 5 bundles packed in a ⅝-bushel hamper, as is customarily done for rail shipments.

(2) Wrapped in wet-moss-peat bundles, covered by paper and tied but not packed in any container.

(3) Without moss peat, left in the burlap bags in which they are customarily delivered to the packing house from the field.

(4) Placed, without moss peat but with wet roots, in burlap bags. (The roots were dipped in water at the packing house and the plants were replaced in the burlap bags.)

In one test 115,500 plants were shipped and in the other 165,500. Temperatures in transit were taken by means of electric resistance thermometers, as was done in the rail tests, and also by mercury hand thermometers.

Table 4 shows that the plants arrived at destination with temperatures within the desirable range of 50° to 70° F. Chiefly because the plants in the first test were warmer to start with, they cooled more during transit than those in the second test. The extent of cooling was influenced by the manner in which the plants were packed as well as by the temperature of the air in the cargo space. In both tests, in fact, the plants in bundles carried in the open arrived with temperatures 3° to 19° cooler than those in hampers or bags, because in the absence of bags or hampers the air circulated more freely among the plants. For the trip as a whole, the temperature of the plants averaged about the same in both hampers and bags.

In table 5 will be found a summary of the temperatures recorded in table 4. It is interesting to note that even though initial temperatures were not identical for the plants in the two tests, the averages for the final temperatures were similar. The rise in temperature of the plants at the first reading in the first test was due to higher air temperatures and a longer delay at loading time.

Ventilation is an important factor in the shipment of living plants by any method. At the beginning of the first flight several of the ceiling ventilators in the plane were open. When it was noted that the relative humidity had dropped to between 20 and 30 percent, these ventilators were closed. On the second flight the ventilators remained closed, but there was adequate ventilation within the cabin. Although the air temperature inside the plane did not fall as rapidly as the outside-air temperature, there was considerable draft within the cabin. There was no stratification of air or of the respiratory gases, judging by the fairly uniform temperatures of plants throughout the entire cargo.

Shipment of tomato plants by airplane resulted in considerable savings in time, the period of transit being reduced from about 36 hours by rail to 5 or 6 by air. Both of these shipments, however, reached their destination when the weather was unfavorable for immediate planting. Consequently there was no practical gain from this method of shipment except information on the savings in time, the savings from modification of the method of packing, and the influence of the different methods of packing on the temperature of the plants. If plants were flown during the night, they could be pulled late one day and transplanted early the next day.

In these tests the plants were loaded into the plane in the same burlap bags into which they had been put after pulling in the field. Some of the commercial growers and shippers who used airplane transportation, however, found it more satisfactory to pack unwrapped plants upright in long keystone-shaped crates.

Table 4.—*Temperatures and other data during shipment of tomato plants by airplane from Tifton, Ga., to Bowling Green, Ohio, 1945*

Test and place	Time	Temperature (°F.)									Relative humidity in cabin	Altitude
		Wrapped bundles	Bags (roots dry)	Bags (roots wet)	Top hampers		Bottom hampers		Air in cabin	Outside air		
					Forward	Midship	Forward	Midship				
Test 1 (May 9):											*Percent*	*Feet*
Tifton, Ga. (loading)	12 m.	70	73	68	70	70	70	70	-----	85	60	-----
Tifton, Ga. (departing)	1:35 p. m.	76	75	69	75	76	68	74	87	65	25	3, 500
En route	2:05 p. m.	68	74	71	75	74	71	71	74	64	30	5, 000
Atlanta, Ga	2:45 p. m.	62	66	64	63	64	59	60	67	77	45	-----
En route	3:30 p. m.	63	71	71	70	69	64	64	82	53	40	7, 000
Do	4:00 p. m.	66	68	71	72	70	63	65	63	48	50	7, 000
Do	4:30 p. m.	66	73	72	75	71	67	64	59	43	60	7, 000
Do	5:00 p. m.	63	70	74	74	71	65	65	57	42	70	7, 000
Do	5:30 p. m.	60	65	71	66	66	56	58	47	37	75	7, 000
Bowling Green, Ohio (arriving)	6:00 p. m.	53	64	72	67	68	56	57	50	40	73	3, 400
Test 2 (May 18):												
Tifton, Ga. (loading)	11:00 a. m.	64	65	66	64	64	64	64	-----	66	-----	-----
Tifton, Ga. (departing)	11:35 a. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
En route	12 m.	56	65	62	70	68	66	61	64	59	48	5, 100
Do	12:30 p. m.	55	65	63	70	68	65	62	63	54	58	5, 100
Do	1:00 p. m.	56	64	62	69	66	65	60	58	47	60	4, 900
Do	1:30 p. m.	54	64	63	70	67	64	60	55	46	65	6, 200
Do	2:00 p. m.	55	65	63	70	68	64	61	57	46	67	6, 200
Do	2:30 p. m.	55	65	63	69	67	62	59	56	45	70	6, 000
Do	3:00 p. m.	54	65	63	69	66	61	59	51	41	80	3, 500
Do	3:30 p. m.	53	64	64	-----	-----	-----	-----	-----	46	-----	1, 400
Cincinnati, Ohio (arriving)	3:35 p. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cincinnati, Ohio (departing)	4:17 p. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
En route	4:30 p. m.	53	65	64	67	65	-----	60	57	51	70	1, 600
Bowling Green, Ohio (arriving)	5:00 p. m.	53	65	64	67	65	60	61	54	50	75	1, 500

TABLE 5.—*Summary of changes in average temperature of tomato plants during shipments by airplane from Georgia to Ohio*

Plants and time of observation	Temperature (° F.)	
	First test	Second test
Plants at loading	70. 2	64. 4
Plants at first reading en route	73. 2	64. 0
Plants at destination:		
Hampers and bags	64. 0	63. 7
Bundles not in containers	53. 0	53. 0
All	62. 4	62. 1

When burlap bags are used there is a saving in packing costs of approximately 85 cents per thousand plants. With this saving, plants could be shipped by air to Pennsylvania and Maryland and sold for approximately $4.55 per thousand as compared with $3.75 for those shipped by railroad.[3] The 80 cents per thousand increase in cost to the northern grower would be compensated for by increased vigor and recovery of plants after transplanting, by the reduction of spoilage loss in shipping, and by savings resulting from the short transit period, which would allow the farmer to utilize available meteorological information and order plants when planting conditions are favorable.

During the 1946 season approximately 30 commercial plane loads of plants were flown out of Georgia. The plants were shipped in keystone-shaped crates rather than burlap bags because a larger load could be accommodated. Wet moss peat was placed on the bottom of the crates. The strings on the bundles were cut and the plants were stood upright. No wrapping was used. In this manner 1,000 to 1,400 plants could be placed in a crate.

RECOMMENDATIONS FOR SHIPPING AND SUBSEQUENT HANDLING

SHIPPING RECOMMENDATIONS

Recommendations of the United States Department of Agriculture for shipment of tomato plants from Georgia within the East follow: When the outside-air temperature at time of loading is between 70° and 80° F., initially ice standard end-bunker refrigerator cars with 5,000 pounds of ice and keep diagonally opposite vents open from loading point to destination. When outside-air temperature is between 80° and 90°, use 6,000 pounds of ice and keep vents open as just indicated. Fan-equipped cars, iced as indicated for standard end-bunker cars, should be used when they are available. Fans should be sealed in the "on" position, and the waybill should be marked "Fans on to destination. Keep vents closed."

[3] HARRIS, T. J. COST ANALYSIS OF TRANSPORTING TOMATO PLANTS BY AIR. Food Packer 28 (11): 51–52, 54, illus. 1947.

Recommendations for shipping tomato plants from Georgia to the Middle West follow: Initially ice standard end-bunker cars with 7,000 pounds of ice and keep diagonally opposite vents open 4 inches from loading point to destination. Use fan cars, iced the same way, when available as specified for shipment in the East.

The hampers or crates of plants should be stacked so as to allow free circulation of air within the car. They should never be stacked higher than the bottom of the top bulkhead opening of the ice bunker.

For airplane shipment tomato plants should be packed with a layer of wet moss peat on the bottom of a keystone-shaped crate and the bundles of unwrapped plants should be stood upright on the moss. The strings on the bundles should be cut.

Handling Southern Tomato Plants After Removal From Cars

The following recommendations for handling tomato plants at destination were made by the New Jersey State Department of Agriculture, Trenton, N. J., on April 1, 1945:

If for any reason, such as unfavorable soil and weather conditions, immediate transplanting is inadvisable, the following procedure of plant handling is recommended.

1. Remove lids from all the baskets.

2. Do not open any bundles until immediately before transplanting. The roots of the plants in the bundle have probably established a water-absorbing connection with the packing material. If this connection is broken the watering recommended later will be less effective.

3. Provide extra baskets, approximately one-fourth the number of baskets of plants to be handled.

4. Remove from each basket:

One bundle if each contains 100 plants.

Two bundles if each contains 50 plants.

Place these removed bundles in the extra baskets. Bundles removed from the baskets should be taken from the middle of the basket.

5. Readjust bundles in the baskets so as to permit free ventilation of all the bundles.

6. Tear a hole in the bottom of the paper wrapper around each bundle. This hole will permit the rapid absorption of water during the dipping and permit immediate drainage after the removal from the water.

7. Place baskets in 3 inches (not over) of water for 5 minutes. Do not wet the top of plants. The plants themselves will absorb little water during the 5-minute wetting period. However, the packing material in each bundle should become saturated, thereby providing a reservoir of water for gradual plant use. Watering of the plants should not continue beyond the recommended 5-minute period.

8. Watered baskets should not be stacked.

9. Desirable storage temperature for baskets of plants is from 50° to 60° F. If stored in a cellar it should be well ventilated. Storage in an outdoor shed is satisfactory if plants are protected from sunlight and drying winds. Remember that proper storage locations and methods will depend upon prevailing weather conditions.

10. A second watering may be necessary. An examination of the tops of the plants will provide the answer.

11. After the bundles are opened, protect plants from intense sunlight and drying winds. Roots should be kept damp.

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